

SEQUENCE OF OPERATION FOR DUAL CONVERTOR SYSTEM

- HEAT EXCHANGER SYSTEM OPERATION:**
- HEAT EXCHANGERS 1-1CA AND 1-1CB SHALL OPERATE IN A LEAD/LAG SEQUENCE. THE DESIGNATED LEAD HEAT EXCHANGER SHALL ROTATE EITHER MANUALLY THROUGH THE BMS OR ON A MONTHLY BASIS (ADJUSTABLE).
 - WHEN ENABLED, THE LEAD HEAT EXCHANGERS 2-WAY, 2-POSITION, NORMALLY OPEN, HOT WATER CONTROL VALVE SHALL OPEN. IF THE LEAD HEAT EXCHANGER FAILS TO MAINTAIN HOT WATER SUPPLY TEMPERATURE, THEN THE LAG HEAT EXCHANGER SHALL ACTIVATE AND THE RESPECTIVE CONTROL VALVE SHALL OPEN.
 - THE CONTROLLER SHALL MEASURE THE HOT WATER SUPPLY TEMPERATURE AND MODULATE THE STEAM VALVE TO MAINTAIN THE HWS SETPOINT.
 - THE STEAM VALVE SHALL BE ENABLED WHENEVER:
 - THE ASSOCIATED HEAT EXCHANGER IS ENABLED.
 - AND PROOF OF PUMP STATUS.
 - THE HOT WATER SUPPLY TEMPERATURE SETPOINT SHALL BE RESET BASED ON DIFFERENTIAL BETWEEN SUPPLY AND RETURN WATER TEMPERATURE. SUPPLY WATER TEMPERATURE DEFAULT SETPOINT SHALL BE 180F (ADJ.) WHEN THE SYSTEM IS STARTED. THE DEFAULT SETPOINT SHALL BE MAINTAINED FROM A MINIMUM TIME OF 30 MINUTES (ADJ.). AFTER THE MINIMUM TIME HAS ELAPSED, THE BMS SHALL ADJUST THE SETPOINT BASED ON THE FOLLOWING FORMULA:
 - $\Delta T = T_{HWS} - T_{HWR}$ IF $\Delta T < 5$ DEGREES, THEN SETPOINT = SETPOINT - 20 DEGREES
 - $\Delta T = T_{HWS} - T_{HWR}$ IF $\Delta T > 5$ DEGREES AND < 10 DEGREES, THEN SETPOINT = SETPOINT - 15 DEGREES
 - $\Delta T = T_{HWS} - T_{HWR}$ IF $\Delta T > 10$ AND < 15 DEGREES, THEN SETPOINT = SETPOINT - 10 DEGREES
 - $\Delta T = T_{HWS} - T_{HWR}$ IF $\Delta T > 15$ AND < 20 DEGREES, THEN SETPOINT = SETPOINT - 5 DEGREES
 - $\Delta T = T_{HWS} - T_{HWR}$ IF $\Delta T > 20$ AND < 25 DEGREES, THEN SETPOINT = SETPOINT + 0 DEGREES
 - $\Delta T = T_{HWS} - T_{HWR}$ IF $\Delta T > 25$ DEGREES, THEN SETPOINT = SETPOINT + 5 DEGREES
 - IF SETPOINT > 120 DEGREES, THEN SETPOINT = VALUE OF SETPOINT ELSE SETPOINT = 120 DEGREES.
 - MAINTAIN NEW SETPOINT FOR A TIME PERIOD OF 15 MINUTES (ADJ.) THEN RECALCULATE SETPOINT.
 - ALARMS:
 - HIGH HW SUPPLY TEMPERATURE (GREATER THAN 190 DEG F (ADJ.)). IF HWS TEMP REACHES 190 DEGREES CLOSE STEAM VALVE, WHEN HWS TEMP FALLS BELOW 180 DEGREES RELEASE STEAM VALVE TO CONTROL LOOP.
 - LOW HW SUPPLY TEMPERATURE (LESS THAN 110 DEG F (ADJ.))
 - IF HWS TEMP FALLS 10 DEGREES BELOW SETPOINT FOR A PERIOD OF 5 MINUTES (ADJ.) GENERATE AN ALARM.
- HEATING HOT WATER PUMP SYSTEM OPERATION:**
- THE HOT WATER DISTRIBUTION TO HEATING EQUIPMENT IN THE SYSTEM IS ACCOMPLISHED BY PUMPS 1-P1A, 1-P1B, AND 1-P1C. THESE PUMPS ARE TO OPERATE LEAD/LAG ORDER WITH ONE OF THE PUMPS SERVING ONLY AS BACK-UP. BOTH LEAD AND LAG PUMPS SHALL BE CAPABLE OF OPERATING IF REQUIRED BY THE DEMAND. THE PUMPS ARE TO BE VARIABLE FLOW AND VARIABLE FREQUENCY DRIVES (VFD) ARE PROVIDED TO CONTROL THE SPEED OF THE PUMPS BASED ON DIFFERENTIAL PRESSURE. THE DIFFERENTIAL PRESSURE SENSOR(S) LOCATED THROUGHOUT THE CONNECTED PIPING SYSTEM SHALL BE USED TO CONTROL THE PUMP SPEED. THE DESIGNATED LEAD PUMP SHALL ROTATE EITHER MANUALLY THROUGH THE BMS OR ON A MONTHLY RUNTIME BASIS (ADJ.).
 - THE PUMP WITH THE FEWEST RUNTIME HOURS SHALL BECOME THE LEAD PUMP.
 - THE PUMP WITH THE SECOND FEWEST RUNTIME HOURS SHALL BECOME THE LAG PUMP.
 - THE PUMP WITH THE MOST RUNTIME HOURS SHALL BECOME THE BACK-UP PUMP.
 - PUMP ROTATION SHALL BE BASED ON TOTAL RUNTIME HOURS. EACH MONTH THE BMS SHALL AUTOMATICALLY CHANGE EACH PUMP DESIGNATION BASED ON TOTAL ACCUMULATED RUNTIME HOURS AS FOLLOWS:
 - THE PUMP WITH THE FEWEST RUNTIME HOURS SHALL BECOME THE LEAD PUMP.
 - THE PUMP WITH THE SECOND FEWEST RUNTIME HOURS SHALL BECOME THE LAG PUMP.
 - THE PUMP WITH THE MOST RUNTIME HOURS SHALL BECOME THE BACK-UP PUMP.
 - THE PUMP CONTROLLER SHALL CONTINUOUSLY SURVEY THE DIFFERENTIAL PRESSURE SENSORS. THE PUMPS SHALL BE CONTROLLED AS FOLLOWS:
 - THE CONTROLLER SHALL MODULATE THE LEAD PUMP VFD TO MAINTAIN THE DIFFERENTIAL PRESSURE SETPOINT.
 - LAG PUMP START-UP, THE LAG PUMP SHALL STAGE ON AS FOLLOWS:
 - IF THE LEAD VFD SPEED IS GREATER THAN A SETPOINT OF 90% (ADJ.) FOR 15 CONSECUTIVE MINUTES (ADJ.), THE LAG PUMP VFD SHALL STAGE ON.
 - THE LEAD PUMP VFD SHALL SLOW DOWN TO 50%, THE LAG VFD SHALL RAMP UP TO MATCH THE LEAD VFD SPEED AND THEN RUN IN UNISON WITH THE LEAD VFD TO MAINTAIN SETPOINT.
 - LAG PUMP SHUTDOWN, THE LAG PUMP SHALL STAGE OFF AS FOLLOWS:
 - IF THE VFD SPEEDS DROP BACK TO LESS THAN OR EQUAL TO 40% (ADJ.) FOR 15 CONSECUTIVE MINUTES (ADJ.), THE LAG PUMP VFD SHALL STAGE OFF.
 - THE LEAD PUMP VFD SHALL CONTINUE TO RUN AND MODULATE TO MAINTAIN DIFFERENTIAL PRESSURE SETPOINT.
 - IF PUMP STATUS IS NOT PROVIDED, AFTER A THIRTY SECOND TIME DELAY, BY THE CURRENT TRANSMITTER AT THE LEAD PUMP, THEN AN ALARM SIGNAL SHALL BE GENERATED, THE LEAD PUMP SHALL BE SHUT DOWN, AND THE BACK-UP PUMP SHALL BE STARTED. AFTER THE CAUSE OF THE ALARM HAS BEEN ELIMINATED, THE SYSTEM SHALL BE CAPABLE OF RESETTING AND RE-ESTABLISHING THE LEAD PUMP.
 - ALARMS:
 - 1-P1A FAIL
 - 1-P1B FAIL
 - 1-P1C FAIL
 - 1-P1A NOT IN AUTO (RUNNING IN HAND OR BYPASS)
 - 1-P1B NOT IN AUTO (RUNNING IN HAND OR BYPASS)
 - 1-P1C NOT IN AUTO (RUNNING IN HAND OR BYPASS)
 - 1-P1A RUNTIME EXCEEDED (IF RUNTIME EXCEEDS 2232 HOURS FOR A THREE MONTH PERIOD)
 - 1-P1B RUNTIME EXCEEDED (IF RUNTIME EXCEEDS 2232 HOURS FOR A THREE MONTH PERIOD)
 - 1-P1C RUNTIME EXCEEDED (IF RUNTIME EXCEEDS 2232 HOURS FOR A THREE MONTH PERIOD)
 - 1-P1A VFD FAULT
 - 1-P1B VFD FAULT
 - 1-P1C VFD FAULT
 - HIGH DIFFERENTIAL PRESSURE (25% (ADJ.) GREATER THAN SETPOINT)
 - LOW DIFFERENTIAL PRESSURE (25% (ADJ.) LESS THAN SETPOINT)
 - HIGH MAIN PRESSURE (100 PSI (ADJ.)) (ET VALUE AT 10% ABOVE PUMP HEAD+FILL PRESSURE)

HEATING HOT WATER RESET SCHEDULE

| OUTSIDE AIR RESET SCHEDULE | |
|----------------------------|---------------------------------|
| OUTSIDE AIR TEMPERATURE | PERIMETER HOT WATER TEMPERATURE |
| ABOVE 60 DEGREES | 120 DEG |
| BELOW 20 DEG | 180 DEG |

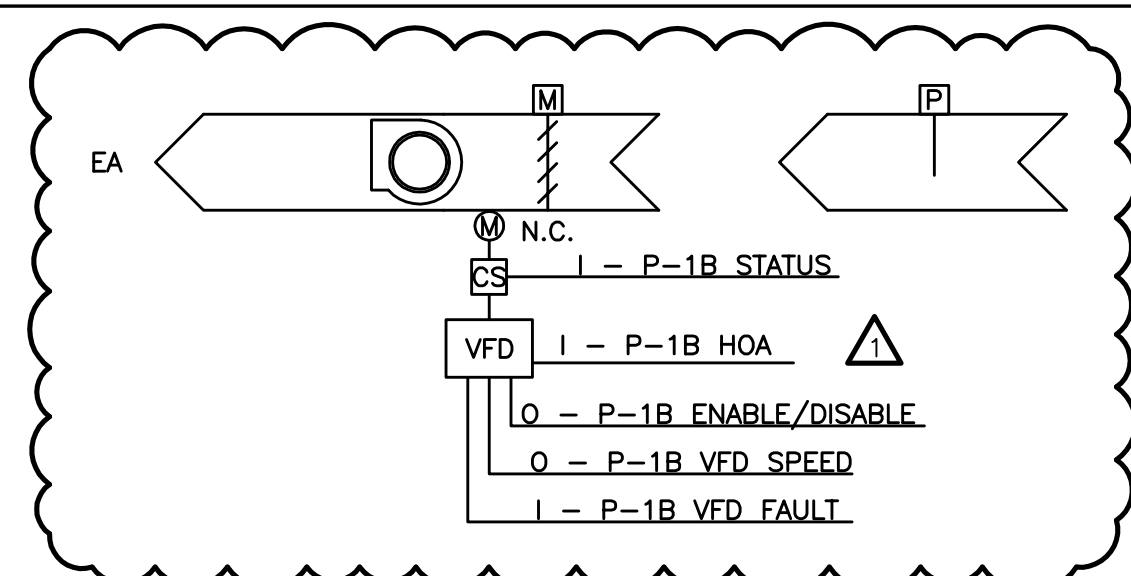
- HOT WATER SETPOINT RESET OPERATION:**
- THE CONTROL OF THE HOT WATER SUPPLY TEMPERATURE SHALL BE VIA AN INVERSE/RESET SCHEDULE. SUPPLY WATER TEMPERATURE SETPOINT SHALL BE 180F (ADJ.) WHEN THE OUTDOOR AIR TEMPERATURE IS 20F (ADJ.) OR LESS. WHEN THE OUTDOOR AIR TEMPERATURE IS 60F (ADJ.) OR GREATER, THE SUPPLY WATER TEMPERATURE SETPOINT SHALL BE 120F (ADJ.). RESET SUPPLY WATER TEMPERATURE LINEARLY BETWEEN THESE TWO TEMPERATURE SETPOINTS.

GENERAL CONTROLS NOTES:

- IN DIAGRAMS, 'I' INDICATES AN INPUT, 'O' INDICATES AN OUTPUT.
- DAMPER OPERATORS SHALL BE PROVIDED BY TEMPERATURE CONTROLS CONTRACTOR.
- TEMPERATURE CONTROL TEST SHALL INCLUDE, BUT NOT BE LIMITED TO:
 - DAMPER OPERATION
 - VALVE ACTUATION RESPONSE AND VALIDATION OF CORRECT OPERATION
 - VERIFIED ENTIRE CONTROL SEQUENCE OPERATES PER DESIGN
 - VERIFY TEMPORARY SEQUENCE OF OPERATION IS ACTIVE SEQUENCE OF OPERATION FOR ALL AIR HANDLING UNITS
 - ACCOUNT FOR ALL CONTROL POINTS LISTED

SUPPLEMENTARY CONTROL NOTES:

- EXTEND THE EXISTING ANDOVER CONTROL SYSTEM. TO PROVIDE A FULLY AUTOMATED DIRECT DIGITAL CONTROL SYSTEM, INCLUDE CONTROL DEVICES, ACTUATORS, WIRING, PANELS, CONTROLLERS, PROGRAMMING, AS SHOWN AND AS REQUIRED TO EXECUTE THE SEQUENCE OF OPERATION. PROVIDE FIELD LABOR AS REQUIRED TO COMPLETE BALANCING AND COMMISSIONING. CONTRACTOR SHALL SUBMIT FOR APPROVAL TO THE VA COTR AND ENGINEER EACH SYSTEM'S SEQUENCES.
- DAMPER OPERATORS TO BE PROVIDED BY TEMPERATURE CONTROLS CONTRACTOR.
 - TEMPERATURE CONTROL TEST SHALL INCLUDE, BUT NOT BE LIMITED TO:
 - DAMPER OPERATION
 - VALVE ACTUATION RESPONSE AND VALIDATION OF CORRECT OPERATION
 - VERIFIED ENTIRE CONTROL SEQUENCE OPERATES PER DESIGN
 - ACCOUNT FOR ALL CONTROL POINTS LISTED
 - ALL SYSTEMS SHALL BE COMMISSIONED. REFER TO SPECIFICATIONS FOR ADDITIONAL INFORMATION.
 - TEMPERATURE CONTROLS SHALL BE ANDOVER. ALL CONTROLS WORK SHALL INTERFACE WITH EXISTING ANDOVER BUILDING CONTROL SYSTEM.

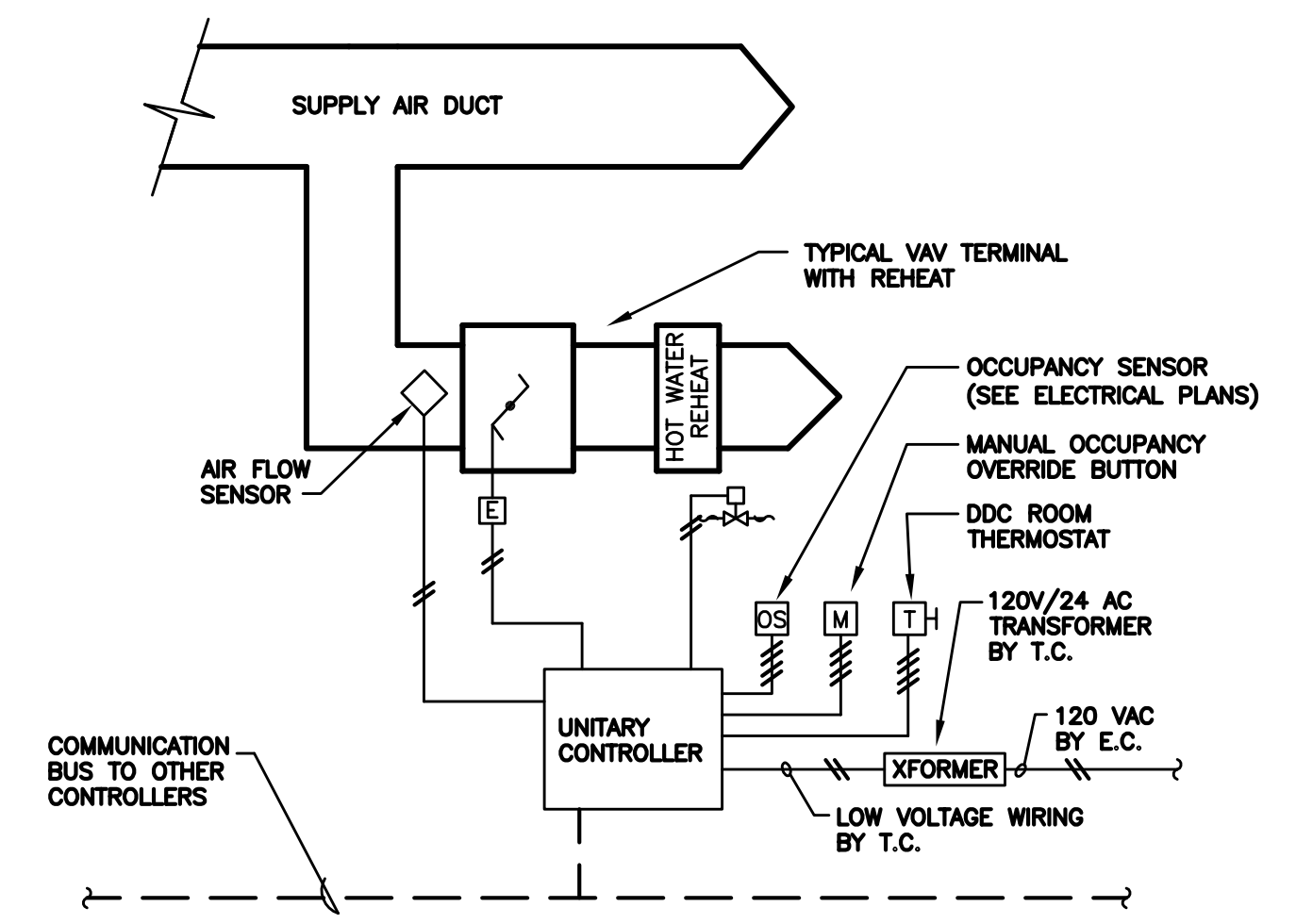


SEQUENCE OF OPERATION:

- EXHAUST FAN EF-1:**
- THE EXHAUST FAN SHALL GENERALLY RUN CONTINUOUSLY.
 - VFD WILL MODULATE TO MAINTAIN PRESSURE SETPOINT.
 - DAMPER SHALL OPEN WHEN FAN IS COMMANDED TO RUN AND DAMPER SHALL CLOSE WHEN FAN IS OFF. DAMPER SHALL HAVE AN END SWITCH WHICH WILL PREVENT THE FAN FROM RUNNING WHEN THE DAMPER IS CLOSED.
- DUCT PRESSURE SENSOR SHALL BE INSTALLED IN DUCT MAIN AT BASEMENT LEVEL. UPON LOSS IN PRESSURE, AN ALARM SIGNAL SHALL BE SENT TO THE BUILDING CONTROL SYSTEM.

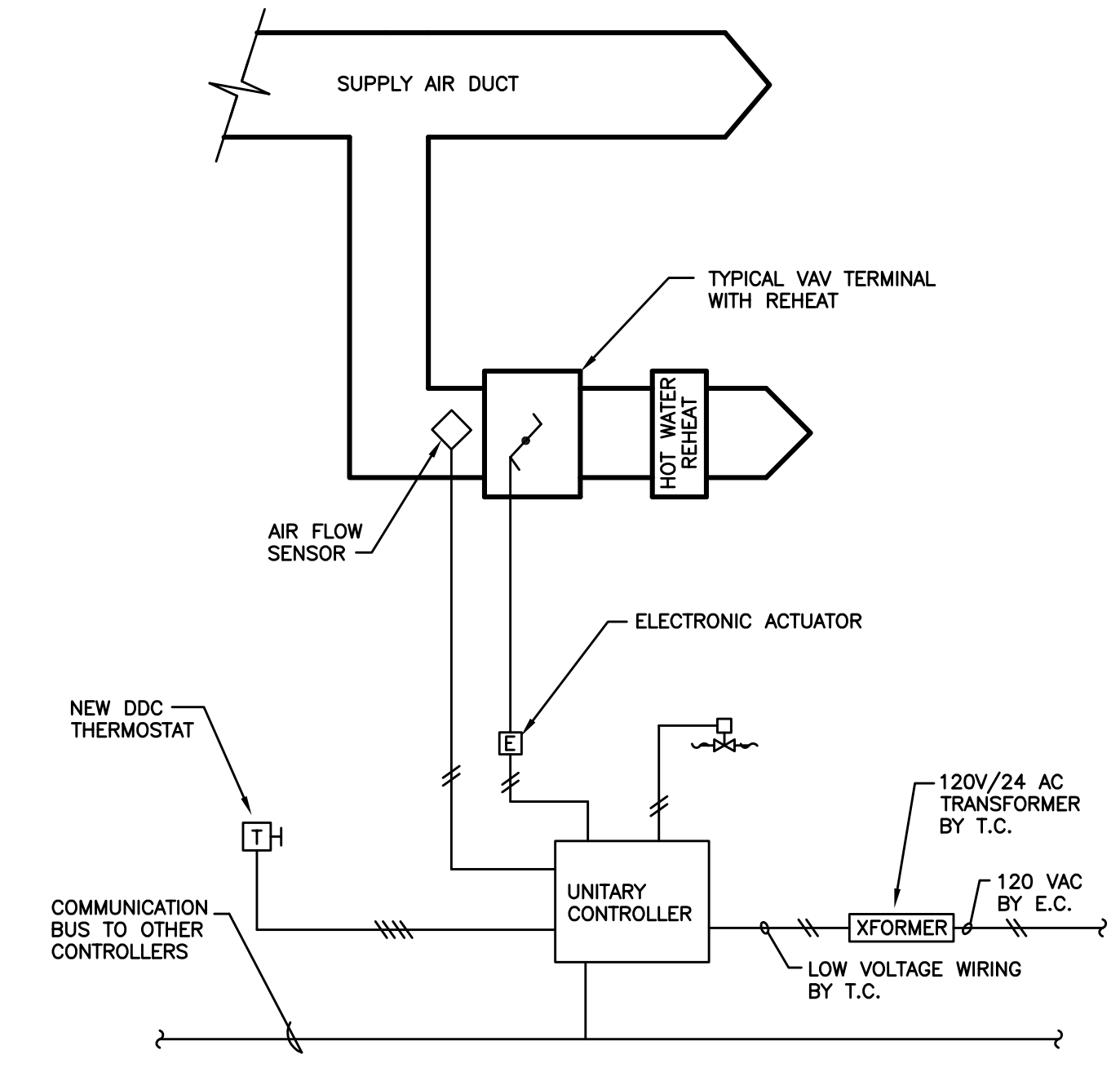
MEDICAL GAS CONTROLS:

- ADDITIONAL SCOPE:**
- TIE INTO MEDICAL GAS AREA ALARM PANEL FOR EACH ALARM MODULE. EACH SHALL GENERATE AN INDIVIDUAL ALARM ON THE BMS.



SEQUENCE OF OPERATION FOR VAV BOXES

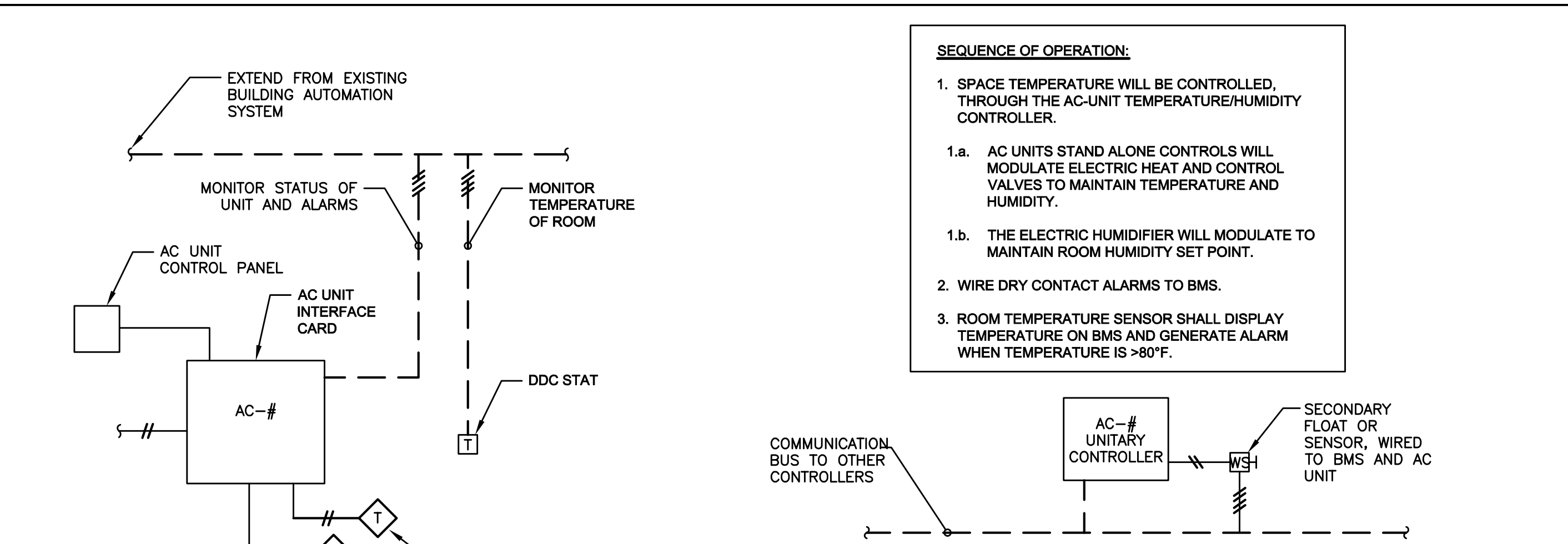
- OPERATION (APPLIES TO BOXES SERVING ROOMS WITH OCCUPANCY SENSORS. REFER TO VAV SCHEDULE):**
- SPACE THERMOSTAT SHALL MODULATE DAMPER TO MAINTAIN SET POINT.
 - ON CALL FOR HEAT, RETURN DAMPER TO MINIMUM POSITION AND MODULATE HOT WATER VALVE TO MAINTAIN SETPOINT.
- OCCUPANCY CONTROL (APPLIES TO CONTROL TYPE 1. REFER TO VAV SCHEDULE):**
- OCCUPANCY SHALL BE DETERMINED FROM OCCUPANCY SENSOR SYSTEM FOR RESPECTIVE SERVICE AREA. CONTRACTOR SHALL TIE INTO OCCUPANCY SENSOR VIA AUXILIARY DRY CONTACTS ON SENSORS. REFER TO ELECTRICAL PLANS FOR ADDITIONAL INFORMATION.
 - ROOM OVERRIDE SHALL BE POSSIBLE FROM MANUAL OCCUPANCY BUTTON. OVERRIDE SHALL BE LIMITED TO 60 MINUTES (ADJ.).
 - OCCUPIED: VAV TERMINAL SHALL OPERATE UNDER STANDARD COOLING/HEATING MODES TO MAINTAIN ROOM THERMOSTAT SETPOINTS AS LISTED IN ROOM DESIGN SCHEDULE ON DRAWING 1-H1.
 - UNOCCUPIED:
 - VAV TERMINAL SHALL RESET TO UNOCCUPIED MINIMUM. UNOCCUPIED MINIMUM SHALL BE 50% OF OCCUPIED MINIMUM (OCCUPIED MINIMUM IS LISTED MINIMUM AIR FLOW IN VAV SCHEDULE).
 - VAV TERMINAL SHALL OPERATE COOLING/HEATING MODES TO MAINTAIN 'UNOCCUPIED' SPACE THERMOSTAT SETPOINTS:
 - UNOCCUPIED SPACE THERMOSTAT SETPOINTS:
 - HEATING: 68° F (ADJ.)
 - COOLING: 78° F (ADJ.)



VAV CONTROL DIAGRAM

- SEQUENCE OF OPERATION:**
- VARIABLE AIR VOLUME TERMINALS:**
- SPACE THERMOSTAT SHALL MODULATE DAMPER TO MAINTAIN SET POINT.
 - ON CALL FOR HEAT, RETURN DAMPER TO MINIMUM POSITION AND MODULATE HOT WATER VALVE TO MAINTAIN SETPOINT.

AC UNIT TEMPERATURE CONTROLS AND SEQUENCE OF OPERATION



SEQUENCE OF OPERATION:

- SPACE TEMPERATURE WILL BE CONTROLLED, THROUGH THE AC-UNIT TEMPERATURE/HUMIDITY CONTROLLER.
- AC UNITS STAND ALONE CONTROLS WILL MODULATE ELECTRIC HEAT AND CONTROL VALVES TO MAINTAIN TEMPERATURE AND HUMIDITY.
 - THE ELECTRIC HUMIDIFIER WILL MODULATE TO MAINTAIN ROOM HUMIDITY SET POINT.
- WIRE DRY CONTACT ALARMS TO BMS.
- ROOM TEMPERATURE SENSOR SHALL DISPLAY TEMPERATURE ON BMS AND GENERATE ALARM WHEN TEMPERATURE IS $> 80^{\circ}F$.

RUN CONDITIONS:

- PROVIDE A SECONDARY FLOAT OR WATER SENSOR, IN THE PUMP RESERVOIR, THAT WILL INDICATE AN OVERFLOW SITUATION AND START THE OVER FLOW SEQUENCE.
- THE OVERFLOW SEQUENCE SHALL INCLUDE THE FOLLOWING:
 - SHUTDOWN THE AC UNIT, HARDWIRED.
 - SEND ALARM TO THE B.A.S., WITH GRAPHICS INDICATING AN OVERFLOW CONDITION.
 - PROVIDE MEANS TO RESET THE ALARM CONDITION AFTER THE PROBLEM HAS BEEN CORRECTED.
 - CONTRACTOR SHALL TEST AND VERIFY SENSOR/ALARM OPERATION.

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